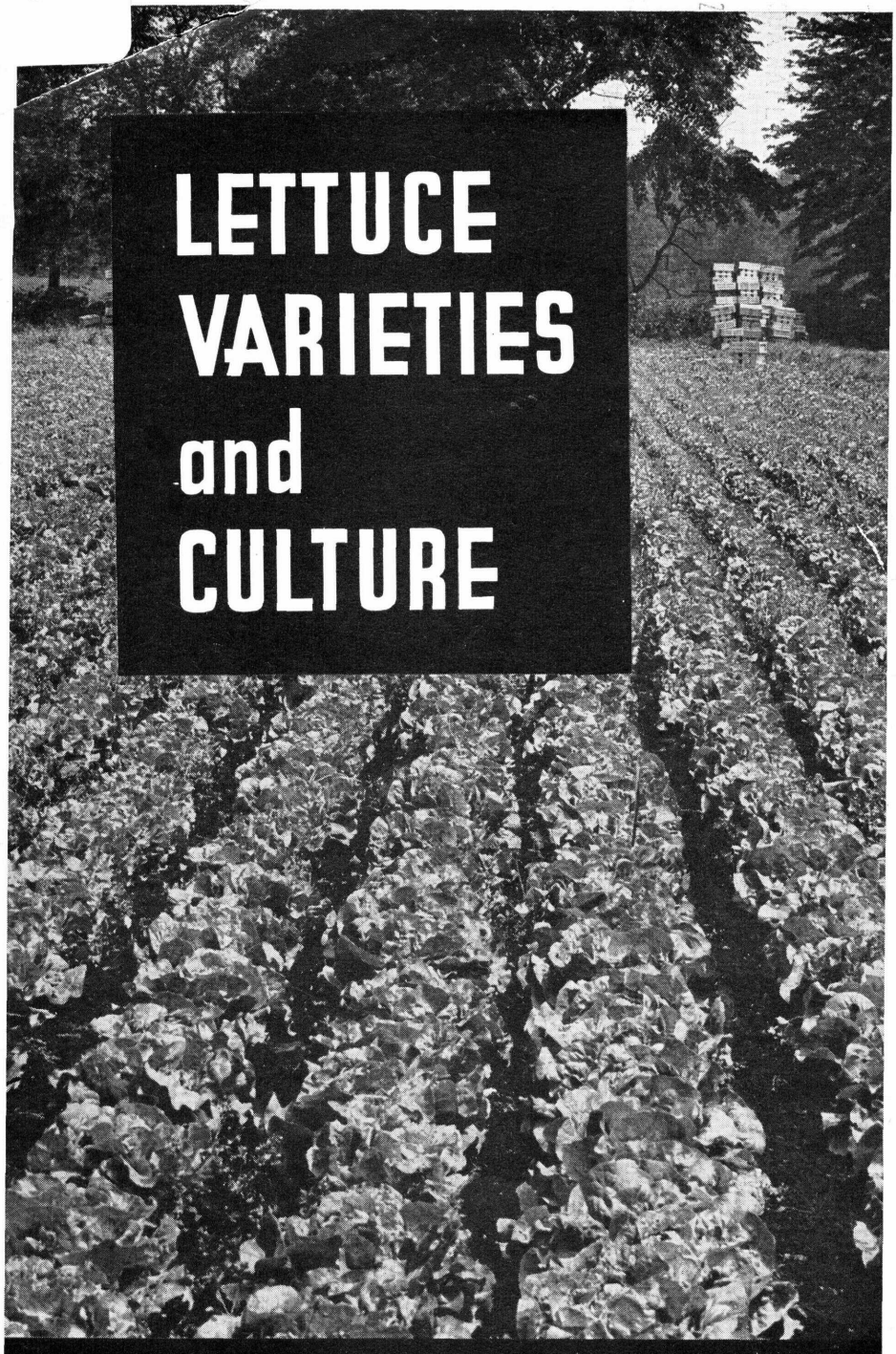

LETTUCE VARIETIES and CULTURE

FARMERS' BULLETIN NO. 1953
U.S. DEPARTMENT OF AGRICULTURE

LETTUCE, especially the green leaves, is an excellent source of vitamin A and supplies some vitamins B_1, B_2, and C, as well as calcium and iron. Because it is eaten raw, lettuce loses none of its vital food elements in preparation for the table, as do cooked vegetables.

The nonheading types of lettuce, which are relatively easy to grow where temperatures are not extremely high, can be grown satisfactorily in most home gardens. Head lettuce, however, is among the most difficult of the vegetable crops to grow to perfection and is not well adapted as a home-garden crop in most areas because of its very exacting climatic and soil requirements.

The commercial outdoor lettuce crop consists mainly of a few highly selected varieties of the crisphead type. These are being constantly improved by breeding and selection for greater uniformity, disease resistance, and adaptation to climatic conditions. Most of the commercial head lettuce is produced in the cool, irrigated districts of some of the Western States and certain favorably located sections in the East. Head lettuce is shipped from the West throughout the year. In the East it is grown mainly as a spring crop.

The growing of good head lettuce in the Eastern States is dependent upon the crop maturing before hot weather. In many localities it is necessary to start the plants in a green house or protected bed in order to bring the crop to maturity during cool weather.

This bulletin supersedes Farmers' Bulletin 1609, Lettuce Growing.

Washington, D. C. Issued May 1944

LETTUCE VARIETIES AND CULTURE

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Contents

IMPORTANCE OF THE LETTUCE CROP

LETTUCE (*Lactuca sativa* L.), the most important salad plant and one of the principal vegetable truck crops, is in demand at all seasons. The commercial crop has a greater annual value than any other vegetable grown for the fresh market. For the period 1931 to 1940, inclusive, it had an average annual value of $28,197,000. In 1941 the value rose to $39,000,000 and in 1942 reached a peak of $60,774,000. These valuations do not include the enormous amount of lettuce grown in home gardens.

This vegetable owes its food value chiefly to its vitamin and mineral contents. It is an excellent source of vitamin A and a good source of vitamins B_1 and B_2 as well as of calcium and iron; it contains some vitamin C. Because it is eaten raw, it loses none of its food elements during preparation for the table. It has taste appeal and because of its low energy value is desirable in low-calorie diets.

Lettuce, a native of India or central Asia, is one of the oldest vegetable crops. The time of its introduction into Europe is not known, but the records of Herodotus, Pliny, Hippocrates, and Aristotle indicate that it was grown as a garden plant in ancient times. It was reported in China as early as the fifth century A. D. and was introduced into America from Europe by the early colonists. Sixteen varieties were listed as being grown in American gardens in 1806.

In the United States the main commercial crops of lettuce are produced in the following regions: (1) The western region, including the Pacific Coast and Rocky Mountain States of California, Arizona,

Colorado, Washington, Oregon, and Idaho; (2) the northeastern region, including Massachusetts, New York, New Jersey, and the States bordering on the Great Lakes; and (3) the South Atlantic region, including Virginia, North Carolina, South Carolina, Georgia, and Florida. The western region produces approximately 85 percent of the commercial crop.

The nonheading types of lettuce, which are not difficult to grow where temperatures are not extremely high, can be grown successfully in most home gardens. The heading type, however, is among the most difficult vegetable crops to grow to perfection because it is very exacting in its climatic and soil requirements and the crop may be greatly damaged by conditions that would have little serious effect on many other crops. A thorough knowledge of the requirements should be obtained before large-scale production of head lettuce is attempted.

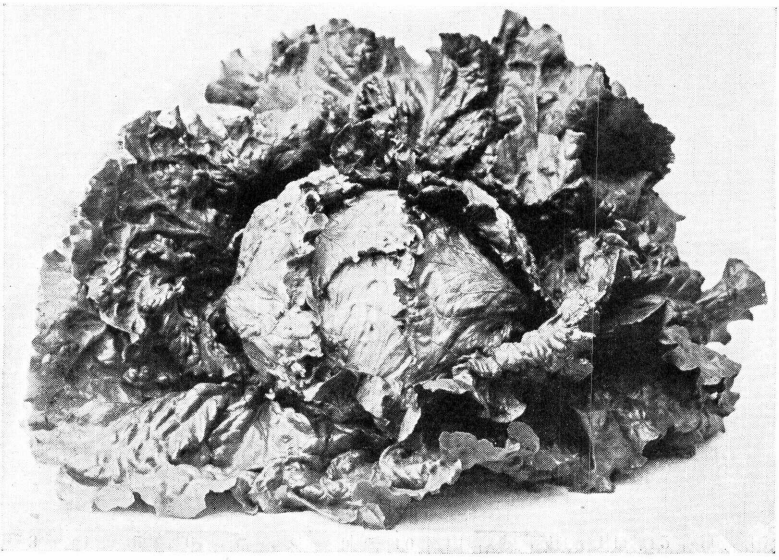
TYPES OF LETTUCE AND THEIR ADAPTATION

The varieties of lettuce may be divided into five general classes, namely: Crisphead; butterhead; cos, or romaine; leaf, or bunching; and stem. Although the culture of all is in general much the same, they differ somewhat in their adaptation to the many conditions under which lettuce is grown. The mature product of each class is distinctly different.

CRISPHEAD TYPE

At present far the most important commercial type is the crisphead. Many varieties of this type are available and new ones are rapidly being added to the list, largely as a result of the breeding work of the United States Department of Agriculture and the State experi-

FIGURE 1.—Head of the New York variety of lettuce, also known as Los Angeles Market and Wonderful. This was the first variety to be sold under the name "Western Iceberg."



ment stations. As these agencies continue to breed and select for disease resistance, adaptation, and quality, new and better strains will no doubt be developed and further changes in the list of important varieties may be expected.

Crisphead lettuce is distinguished by its firmness of head and crisp texture. Firmness of head is no doubt chiefly responsible for the enormous increase in the commercial importance of this type, because it makes it much better adapted for shipping than other types. The shipping qualities of crisphead lettuce along with advances in methods of packing, transportation, and refrigeration have made it possible to produce large quantities of lettuce in the areas best adapted by reason of climate and soil conditions and to deliver it in good condition to consumers in distant markets. Nearly all the commercial lettuce crop grown in the Western States is of the crisphead varieties.

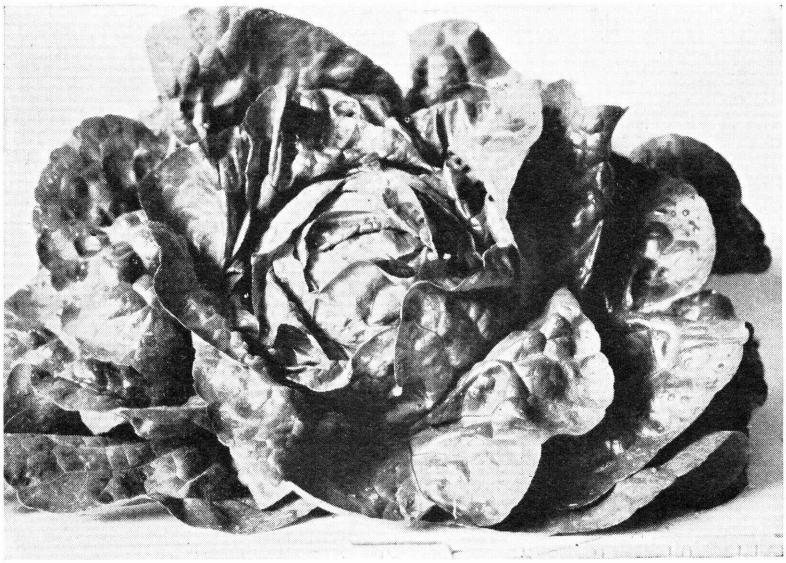
Some important varieties of this type are New York, or Wonderful (fig. 1); New York No. 12; New York No. 515; Imperial 152; Imperial 847; Imperial 850; Imperial 615; Imperial D; Imperial 44; Hanson; Iceberg; and Mignonette.

BUTTERHEAD TYPE

The butterhead type of lettuce is distinguished by its soft heads, the inner leaves of which feel oily or buttery. Among the important varieties are Big Boston (fig. 2), White Boston, Salamander, May King, Wayahead, and Deacon.

Before the enormous expansion of the crisphead lettuce industry in the Pacific Coast and the Mountain States much of the commercial lettuce crop was grown in the truck-growing areas near the large eastern cities and in suitable localities along the Great Lakes and in the Atlantic Coast States. Most of this was of the varieties Big Boston and White Boston.

FIGURE 2.—Typical head of Big Boston lettuce.



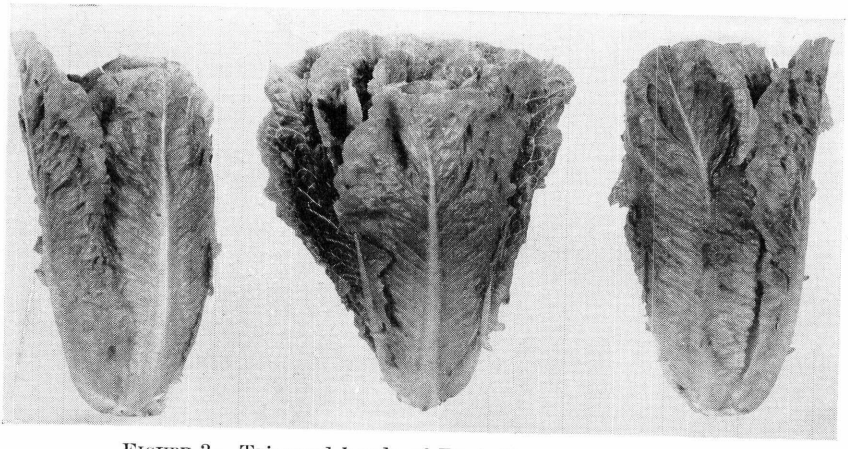


FIGURE 3.—Trimmed heads of Dark Green, a cos variety.

As the crisphead lettuce industry expanded in the West there was a marked decline in the demand for and the production of butterhead lettuce. Since it is now difficult to sell this type in most markets in competition with the crisphead type, many vegetable growers near the eastern markets are now growing the crisphead varieties. Some butterhead lettuce, however, is still grown as an early crop in the eastern lettuce regions because some people and some markets prefer it to other kinds.

COS, OR ROMAINE, TYPE

The varieties of the cos, or romaine, group are distinguished by their elongated heads, stiff leaves, and upright habit of growth. The best cos varieties are Paris White and Dark Green (fig. 3).

Although popular and long grown in Europe, the cos varieties have never been grown extensively in this country. They are considered by some to be the best of all types in quality. Although the leaves are somewhat coarse they are sweet and of good quality and generally have less of the bitterness characteristic of some of the other types.

Cos lettuce is less adapted to shipping than either the crisphead or the butterhead type; hence it is more difficult to deliver to the consumer in good condition. Its poor shipping qualities have no doubt limited its commercial production, but it is well adapted to the home garden.

LEAF, OR BUNCHING, TYPE

Leaf, or bunching, lettuce is distinguished by its loose, non-head-forming leaves. This is the most important type for the home garden, since it can be grown in areas where the temperature is too high for successful production of other kinds of lettuce.

The most important leaf varieties are Black-Seeded Simpson, Grand Rapids (fig. 4), Prize Head, and Early Curled Simpson.

Leaf lettuce is much better adapted to growing under glass than the other types. Most of the lettuce now grown in greenhouses is of various strains of the Grand Rapids variety.

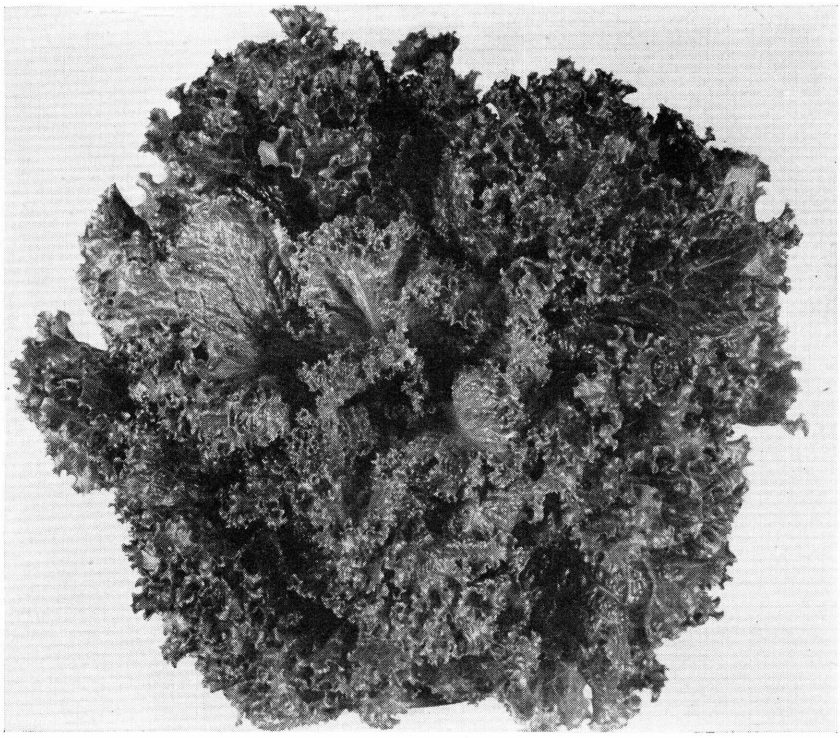


FIGURE 4.—A plant of Grand Rapids leaf lettuce.

STEM TYPE

Stem lettuce is distinguished by its much enlarged stem and the absence of a head (fig. 5). Although the leaves are edible they are not as palatable as those of the other types, except possibly while they are very young and tender. Stem lettuce is grown principally for its large fleshy stems, which are peeled and eaten raw or cooked. There are several varieties and strains, but seed of only one, sold under the name of Celtuce, is now offered for general sale by seedsmen.

Stem lettuce has not been grown and used widely enough in this country for its adaptation and probable future importance to be fully determined.

DESCRIPTION OF IMPORTANT VARIETIES

The list of lettuce varieties includes some 1,100 names, but nearly all the important varieties have been listed under several names. The variety Salamander, for example, has been cataloged under 50 different names. There are about 150 distinct varieties, of which some 20 or 25 are commercially important.

The commercial pack of the several strains of the varieties New York and Imperial from the Western States is marketed in the East under the name "Iceberg," or "Western Iceberg," lettuce. It is regrettable that the term "Iceberg" has been applied to these varieties. The true Iceberg variety has been in existence for many years and is distinctly different from the varieties New York and Imperial, to which the name has been erroneously applied by shippers and produce dealers.

FIGURE 5.—A plant of stem lettuce.

The following are among the most important commercial varieties of lettuce.

CRISPHEAD VARIETIES

New York.—A very large, dark-green, late, slow-bolting variety. Leaves broad, fairly heavily blistered, crumpled, thick, and coarse (fig. 1). Texture very firm, crisp; quality good. Seed whitish.

This variety was first introduced into this country in 1896 by Peter Henderson & Co. Although generally known by the name New York, it is also called Wonderful and Los Angeles Market. New York is an excellent shipping variety and the one first shipped to the eastern markets as "Iceberg" or "Western Iceberg." It was formerly the leading crisphead variety and the one on which the present lettuce industry of the West was built. It has been largely displaced by new disease-resistant and better adapted strains, most of which have New York as a parent.

New York No. 12.—A large, late, dark-green lettuce; a little earlier and lighter green than New York. Head large, firm, somewhat exposed or bald. Seed whitish.

New York No. 12 was developed and introduced by the Pieters-Wheeler Seed Co. It was formerly the best adapted of the crisphead varieties for commercial planting in the eastern part of the United States. Although more resistant to tipburn than most of the Imperial strains, it is being rapidly displaced by Imperial 847 in the important eastern commercial sections because it does not head so well as some others in warm weather.

New York No. 515.—An early, tipburn-resistant, medium-sized, dark-green lettuce. Plant upright in habit in early stages. Head round, firm, and well-formed. Seed whitish.

New York No. 515 was developed by the Pieters-Wheeler Seed Co. from a cross between the regular New York and the true Iceberg. An improved strain of the variety has been developed, and because of its greater tipburn resistance it has replaced other New York strains in districts where tipburn is severe.

Imperial 847.—A large, late, dull-green lettuce. Leaves large, savoyed, and crumpled, and slightly curled at the margins. Heads large, round, and partially exposed, but with abundant wrapper leaves (fig. 6). Texture firm, crisp; quality good. A relatively sure header and slow to bolt. Seed black.

Imperial 847 was developed and introduced by the United States Department of Agriculture and the California Agricultural Experiment Station in 1936. It is one of the best and most widely adapted of the Imperial strains. It is not

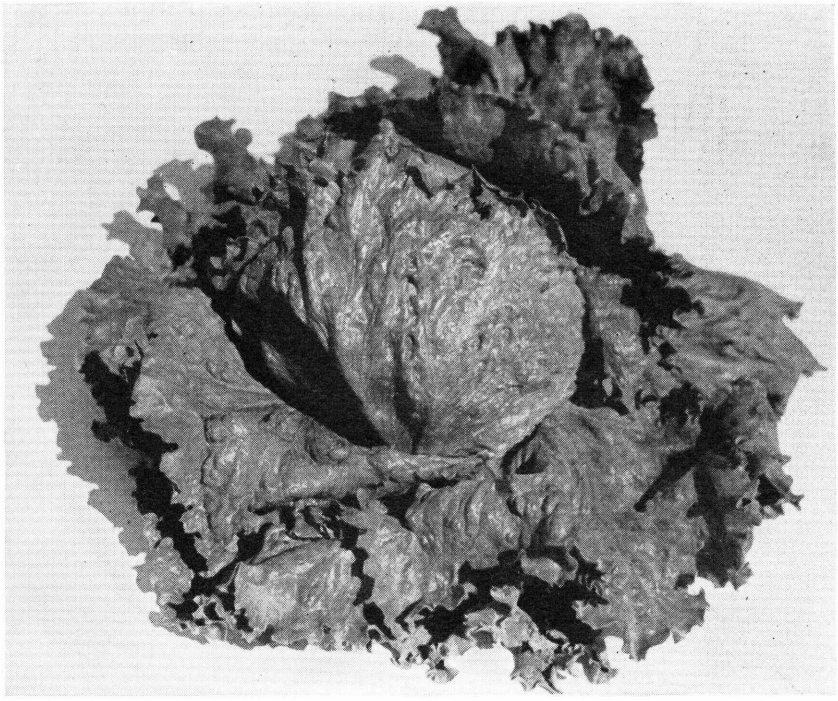


FIGURE 6.—Head of Imperial 847 lettuce.

only one of the leading commercial varieties in California, Arizona, and other Western States, but it is rapidly becoming the most widely planted crisphead variety in the Eastern States. It is resistant to brown blight and to certain forms of downy mildew.

Imperial 152.—A large, medium-early, medium-dark-green, slow-bolting lettuce. Leaves large, broad, blistered and crumpled, and slightly curled at the margins. Heads round, firm, slightly flattened on top, partially exposed. Texture crisp; quality good. Seed whitish.

Imperial 152 was developed and introduced by the United States Department of Agriculture and the California Agricultural Experiment Station. Although one of the leading commercial varieties for early planting in California and Arizona, Imperial 152 is too susceptible to tipburn to be adapted to eastern climatic conditions. It is resistant to brown blight and certain forms of downy mildew.

Imperial 615.—A very large, late, gray'sh-green lettuce. Leaves broad, only moderately savoyed and crumpled, fairly thick, and coarse. Plant has a spreading habit of growth. Heads very large, slightly flattened on top, partially exposed, surrounded by many wrapper leaves, firm; quality good. Seed whitish.

Imperial 615, one of the largest of the commercial varieties, was developed and introduced by the United States Department of Agriculture and the California Agricultural Experiment Station in 1934. It is the most important variety in the Imperial Valley of California and is planted extensively in other Western States. It is primarily a cool-weather lettuce. On account of its susceptibility to tipburn and its tendency to become oversized and ribby in warm weather, it is not adapted to eastern conditions. It is resistant to brown blight and some forms of downy mildew.

Imperial 44.—A medium-sized, late, grayish-green, crisp lettuce. Leaves long, moderately savoyed, and crumpled. Heads very firm, well covered by wrapper leaves, tending to conical in shape under some conditions. Texture firm and crisp; quality good. Seed whitish.

Imperial 44 was developed and introduced by the United States Department of Agriculture in cooperation with the New York (Cornell) Agricultural Experi-

ment Station. Although now grown in some of the Western States, it was developed and selected largely for its adaptation to the muck lands of New York State. Imperial 44 is a little darker green than Imperial 847, produces hard, well-formed, well-wrapped heads, and is one of the slowest bolting of the commercial crisphead varieties. It generally matures a few days ahead of Imperial 847. On account of its greater tendency to tipburn it is being rapidly displaced by Imperial 847 in many of the eastern lettuce-growing districts.

Iceberg.—A large, late, slow-bolting, yellowish-green lettuce having a tinge of reddish-brown pigment at the margins of the leaves. Leaves very broad, thick, and stiff, fairly savoyed and crumpled; has heavy midrib. Heads firm; texture crisp; quality good. Seed whitish.

Iceberg was introduced from Europe and named by the W. Atlee Burpee Co. about 1894. This is the true Iceberg variety and should not be confused with the New York and Imperial strains that are marketed under the misleading name of "Iceberg." It is one of the more reliable of the older crisphead varieties and probably the most resistant to tipburn of all of the crisphead varieties. On account of its more rapidly bolting habit it is not as sure a header as the new Imperial strains.

Hanson.—A large, late, yellowish-green, slow-bolting, crisp lettuce. Plants spreading but producing a well-defined head. Leaves broad, fairly savoyed and crumpled, thick, coarse, with heavy midrib. Texture crisp but coarse; quality very good. Seed large and whitish.

Hanson, introduced by Henry A. Dreer, Inc., about 1875, is probably the most widely grown of the older crisphead varieties. Although not important commercially, it is desirable for the home garden.

BUTTERHEAD VARIETIES

Big Boston.—A medium-large, dull light-green lettuce, intermediate in season; shooting to seed early. Plants upright in early stages but maturing with well-formed, broad, slightly pointed heads (fig. 2). Leaves very broad, fairly smooth, slightly crumpled, thick but not easily broken. Head firm for a butterhead variety. Texture coarse; quality fair. Seed whitish.

Big Boston, introduced by Peter Henderson & Co. about 1870, is probably the most widely distributed variety in cultivation, being listed by practically every seedsman in America and also in Europe, where it is known as Trocadero. There are numerous strains of the variety. It was formerly planted extensively for carlot production in the eastern part of the United States, but like other butterhead varieties it has been largely replaced by crisphead ones. It has a decided tendency to tipburn.

White Boston.—Characteristics same as those of Big Boston except that most strains are lighter green and all are free of the reddish-brown pigment characteristic of Big Boston. Seed whitish.

White Boston has replaced Big Boston in many of the districts that grow butterhead varieties. Although still popular where butterhead lettuce is grown, it has been largely displaced by crisphead varieties.

Salamander.—A medium-large, midseason, light-green, fairly rapidly bolting lettuce. Plant compact or slightly spreading. Leaves broad, much savoyed and crumpled, thin, and soft. Head globular, fairly firm, and well blanched. Texture soft; quality excellent. Seed brownish-black.

Salamander is often called Black-Seeded Tennisball. It has probably been sold under more names than any other lettuce. Since it withstands hot weather better than most butterhead varieties, it is a popular local-market and home-garden lettuce.

May King.—An early, small, light-green lettuce tinged with reddish-brown pigment (fig. 7). Plant upright in early stages. Leaves short, broad, crumpled but smooth at edges. Head small to medium in size, compact, with creamy-yellow interior; quality excellent. Seed whitish.

May King is one of the favorite butterhead varieties for the home garden, especially in the northeastern part of the United States. It is well adapted for coldframe and early outdoor culture, but scorches easily; hence it is not adapted for late planting.

Wayahead.—A small, early, medium dark-green variety. Plant small to medium, compact, with few outer leaves. Head small but fairly solid; quality excellent. Seed whitish.

Wayahead is a popular small butterhead lettuce well adapted for early-spring and fall culture out of doors.

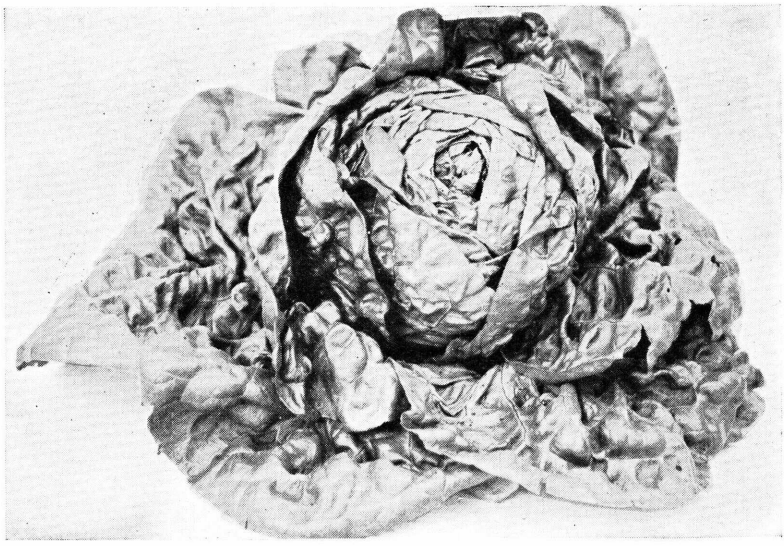


FIGURE 7.—Head of May King lettuce.

COS, OR ROMAINE, VARIETIES

Paris White.—A large, late, medium-green, slow-bolting cos variety. Plant large, upright, self-closing. Leaves long-oval to slightly spatulate, only slightly savoyed, thick, stiff, coarse. Texture crisp and coarse; quality excellent. Seed whitish.

Paris White, also known as Trianon, is probably the most popular of the cos varieties. This is a very high-quality lettuce. Most of the varieties of this type of lettuce are of European origin.

Dark Green.—Characteristics same as those of Paris White except for being darker green, a little shorter, and more open at the top of the head (fig. 3). A high-quality lettuce. Seed whitish.

LEAF, OR BUNCHING, VARIETIES

Grand Rapids.—An early to midseason, yellowish-green, early bolting lettuce (fig. 4). Plant spreading in early stage but becoming fairly compact at maturity. Leaves long, spatulate in shape, heavily blistered, crumpled, with thick midribs, much frilled at margins. Texture coarse; quality poor. Seed black.

Grand Rapids was originated many years ago by Eugene Davis, a market gardener of Grand Rapids, Mich. It is still one of the best known and most widely grown of the leaf varieties. It is the most extensively used of all varieties for growing under glass and is well adapted for spring planting out of doors, especially in the Northern States. The much-frilled leaves of Grand Rapids make it especially desirable for garnishing.

There are several strains of Grand Rapids, each adapted to specific conditions or having resistance to certain diseases. Seed of Grand Rapids is often difficult to germinate.

Black-Seeded Simpson.—A large, yellowish-green, slow-bolting leaf lettuce, early to intermediate in season. Plant large, compact, somewhat upright in habit of growth. Leaves very broad, heavily savoyed and crumpled, thick, and coarse. Texture crisp and coarse; quality fair. Seed large, blackish.

Black-Seeded Simpson, a very old variety listed first by Peter Henderson & Co., is the most widely adapted and one of the best of the leaf varieties. It is one of the best of all varieties for growing in hot weather.

Early Curled Simpson.—An early to midseason, medium-sized, yellowish-green, slow-bolting lettuce. Plant spreading. Leaves short spatulate to broad, heavily savoyed and crumpled, thick and stiff, frilled at the margins. Texture hard and coarse; quality fair. Seed large, whitish.

Early Curled Simpson, sometimes called White-Seeded Simpson, is distinctly different from the Black-Seeded Simpson. It is one of the most popular of the leaf varieties. It withstands the heat of early summer and thrives better under adverse conditions than most other varieties of lettuce. It is used extensively by market gardeners for hotbed culture and is a good home-garden variety.

STEM LETTUCE

Celtuce.—A large-leaved, thick-stemmed, dull dark-green, slow-bolting lettuce (fig. 5). Plants large and spreading. Leaves long, slightly spatulate, with few blisters, thick, and coarse. Stems very thick. Quality of core good. Seed whitish.

Celtuce is the only variety of stem lettuce grown commercially in this country. The stems are very thick, reaching a diameter of 2 inches or more if grown on fertile soil during cool weather. In warm weather the stems elongate rapidly and never develop the thickness attained at lower temperatures. The raw or cooked core of the stems is much liked by some people.

FACTORS INFLUENCING FIELD PRODUCTION

Although one or more of the several types of lettuce can be grown in nearly all parts of the United States, the production of the heading varieties on a commercial scale is very much localized because of the climate limitations.

Temperature, moisture, and soil are all important in the successful production of lettuce under field conditions; however, temperature is most frequently the limiting factor. Lettuce, especially the heading varieties, requires a relatively low average temperature, particularly during the latter part of the growing period. The principal reason for their failure to produce heads is that the seed stems begin to elongate, or bolt, before the heads reach maturity. This causes a separation of the leaves at the base and results in a loose or puffy head. If the bolting starts early it may prevent heading altogether. The influence of temperature on the development of the seed stem is a very critical factor in the production of head lettuce in areas where the temperature is high during a large part of the growing season.

Head lettuce could be grown successfully as a fall crop in many parts of the East, except for the fact that the temperature during the first half or more of the growing season is so high that the seed stem in most varieties begins to elongate before the weather becomes cool and favorable. Once the seed stem begins to elongate, further development cannot be prevented regardless of how favorable the growing conditions may be thereafter. Much has been done through the breeding work of the United States Department of Agriculture and the State experiment stations to overcome the hazard of premature bolting by the development of new slow-bolting varieties. These withstand higher temperatures for a longer time before shooting to seed than do the old standard varieties like New York and Big Boston.

The development of the seed stem is accompanied in most cases, especially during warm weather, by an increase in the bitterness characteristics of many varieties.

Head lettuce is much more susceptible to injury from unfavorably high temperature during the last few days before it reaches maturity than earlier in its development. During this period the leaves, especially those forming the outer covering of the head, become susceptible to the malady known as tipburn (p. 28).

In some localities, the South Atlantic States in particular, hard, untimely freezes during the period just following the transplanting

of the seedlings from the plant beds to the field frequently interfere with field production of both the heading and the cos types.

Unfavorable moisture supply frequently prevents normal growth of lettuce, particularly throughout the eastern districts. Most of the western crop is grown under irrigation, where soil moisture is largely under the control of the grower. Lettuce requires a fairly abundant and constant water supply. Low soil moisture is extremely injurious to head lettuce except during the very early stages, when the rate of growth may be severely checked and the maturity of the crop delayed. Even a few days of very low soil moisture may be ruinous to a lettuce crop in the late stages of development. Many lettuce growers in the East could greatly increase both the yields and the quality of their crops by the installation of irrigation systems where water for irrigation is available.

Although lettuce has a high soil-moisture requirement it will not thrive under conditions of excessive soil moisture. Prolonged heavy rains, with water standing near or on the surface for even a few days, may do great damage. Excessive rainfall and low temperature often cause damage to lettuce when grown as an early-spring crop.

Since the soil-moisture content is one of the important factors in successful field production of lettuce, the Western States, where the crop is grown almost entirely under irrigation, have a decided advantage over the Eastern States, where regulation of soil moisture is largely out of the control of the grower. Even where irrigation is used in the East the grower does not have as complete control of the soil moisture as in the West, because of heavier and more frequent rains. Heavy rains after the heads begin to form may cause great loss by upsetting the growth rate of the plant, especially on fertile soil high in available nitrogen. The damage done by a sudden change in soil moisture at this time is likely to be greatest if the crop has been growing with somewhat less than optimum moisture. A sudden increase in soil moisture with the resulting rapid growth at any time after the heads have begun to form may interfere with the normal folding in of the leaves, thereby preventing the formation of a solid head. Any increase in the space between the bases of the leaves after they have begun to tighten over the head is likely to result in large puffy heads. Only when very favorable temperature and moisture supply prevail for several days after such a loosening of the leaves is it possible for firm heads to develop.

Soil, the third of the three factors mentioned as being the most important in the field production of lettuce, is only relatively less important than temperature and moisture. Sometimes the physical state of the soil, its lack of the proper amounts and balance of plant nutrients or other unfavorable conditions may prevent a lettuce crop from being profitable. In most cases, however, soil conditions are more nearly within the grower's control than either temperature or moisture. Many of the troubles associated with the soil can be corrected by practical methods.

Lettuce is one of the most sensitive of the vegetable crops to the acid-alkaline balance of the soil. In general the reaction of the soil should be nearly neutral. In many parts of the East the soil is too acid for the maximum growth of lettuce and lime must be applied to correct this condition. Extremely acid soils should be avoided or the reaction adjusted by the application of lime a year or two previous to planting the lettuce, so as to permit the soil reaction to come

to a state of balance. Heavy applications of lime may be injurious in some cases. Under eastern conditions it is best to maintain a slightly acid reaction (pH 6.0 to 6.5) since experimental evidence indicates that an alkaline reaction may be harmful.

In the irrigated sections of the West the soil reaction is generally one of too-high alkalinity. In these arid soils alkali salts tend to accumulate in harmful amounts, especially in low areas where irrigation water stands or where alkali salts are leached from higher to lower levels. Soils high in alkali should be avoided for lettuce.

Soil problems in relation to lettuce production are discussed in more detail below.

ROTATIONS

Lettuce should not be grown too frequently upon the same land, but some system of crop rotation should be followed. Plants of the same family are often subject to the same diseases and insect enemies. Endive, chicory, dandelion, and other members of the lettuce family should not be used in a rotation with lettuce, as this would tend to defeat one of the important purposes of rotation, the reduction or elimination of soil-borne agents that cause diseases. Some of the most serious of the lettuce diseases can be controlled only by sanitary field conditions. Crop rotation is very important in areas subject to epidemics of drop, bottom rot, big vein, and other diseases that may be carried over in the soil.

Crops should be selected for a rotation that are adapted to the locality and can be fitted into the general plan of farm operations. Deep-rotted plants like alfalfa and clover are well adapted for use in a rotation with a shallow-rooted crop like lettuce. Some of the small grains and forage crops like rye, wheat, soybeans, vetch, and cowpeas may be used in a rotation with lettuce, as they are not subject to the diseases common to lettuce. Vegetable crops that are not usually attacked by the agents that cause diseases in lettuce are beets, cucumbers, melons, onions, pumpkins, radishes, spinach, sweet corn, and tomatoes.

Crop rotation is also important in maintaining soil fertility. Plants differ in their feeding capacities in that they remove the various elements from the soil in different amounts. Frequent growing of a crop on the same land may deplete the soil of certain essential materials.

SELECTION, PREPARATION, AND IMPROVEMENT OF SOILS

SOIL REQUIREMENTS

Soils vary in their mineral and organic-matter content from those that are almost wholly mineral, like certain very sandy soils, to those that are highly organic, like muck. The fertility of a soil, that is, its capacity to produce a satisfactory crop of any particular plant under favorable climatic conditions is dependent upon the presence of many chemical elements in forms available for plant growth. Some of the constituents of a fertile soil contribute to the plant's growth largely by improving the physical and water-holding capacity, as does humus. Some serve largely by making other elements more available to the plant. This is one of the functions of lime. Elements such as nitrogen, phosphorus, potash, magnesium, iron, and manganese help to build new plant tissues.

These brief statements regarding the complexity of soil composition are given to point out the extreme variability that may exist among different soils in their natural fertility or capacity to support growth and to show how unwise it is to make recommendations for improving the crop-producing capacity of a soil without considering specific information regarding its composition and the amount and kinds of fertilizing materials previously applied.

Farmers know that fields and even different parts of the same field differ in their crop-producing capacities. To obtain uniform fertility would require the application of different elements in different amounts to different parts of a single field. This is of course impractical. The differences in producing capacity are greatly magnified from one field to another and from one locality to another. To increase the crop-producing capacity of any piece of land, the grower must determine its specific requirements largely by observation. He must note the response of his crops to any given fertilizing material, take into consideration the amount of the different fertilizing elements previously applied, and consider to what extent such materials may have been removed by crops or lost through leaching by rain or irrigation water. The inexperienced should follow closely the practice of the most successful growers in the locality.

Lettuce is grown successfully on a wide range of soil types from clay loams to sandy loams and muck, but it reaches its highest quality on fertile loams that are not too light in texture and contain large amounts of organic matter. Very light soils low in organic matter are not adapted to lettuce growing. Upland soils of this kind are very unsatisfactory. Fluctuation of the moisture content is one of the principal reasons why very light mineral soils should be avoided for the growing of lettuce. Light soils can be used to best advantage for a lettuce crop that makes most of its growth and matures during cool weather.

Contrary to a rather general belief, lettuce does well on heavy clay. Soils of this type are difficult to work, but when properly handled, they yield excellent crops. Well-drained muck produces good lettuce. Its high organic content gives it a high water-holding capacity and affords a more uniform moisture supply than can be attained on other kinds of soil.

Soils that have a tendency to crust on the surface may not produce a satisfactory stand of plants, especially if the surface is puddled by heavy rain after planting and before the seedlings emerge.

Lettuce is a relatively expensive crop to produce, but when properly grown it promises high returns per acre. A good crop of lettuce cannot be grown on land in a low state of fertility. Considering the extreme complexity and variability of soil in its composition and crop-producing capacity, it is obvious that only general recommendations can be given in a bulletin of this kind; it can point out only some of the essential characteristics of a highly productive lettuce soil and leave it to the grower to approach these standards as closely as possible with the methods and materials available to him.

BUILDING ORGANIC MATTER

High organic content is one of the prime requirements of a soil for lettuce culture. Western soils are more generally lower in organic matter than the soils in the East. There is probably no better source

of organic matter than well-decomposed barnyard manure, but animal manures from various sources and kinds of animals differ greatly in content of nutritional elements. Poultry, swine, and sheep manures are very high in nitrogen as compared with horse and cattle manures, rating in the order named. Manure fresh from the stalls or poultry yard is likely to be much higher in the nutritional elements, especially nitrogen, than manure that has been piled and permitted to ferment or that has been exposed to leaching by rains. The kind and previous treatment of any manure must be taken into consideration in estimating its value for increasing the productive capacity of a soil. Additional fertilizing elements from other sources will be required where manure that has been leached or permitted to ferment is used.

Fresh undecomposed manure, strawy manure, or that containing coarse material should be applied and thoroughly incorporated with the soil long enough in advance of planting the lettuce crop to permit it to decompose. Strawy manure incorporated with the soil just before planting may damage the lettuce crop by causing a temporary shortage of nitrogen, and a bad physical condition may accompany the decomposition of the unrotted organic material. Coarse, strawy manure has a tendency to leave the soil too porous or trashy and may increase the danger of injury from a shortage of moisture in dry weather.

In localities where barnyard manure is not available the organic matter of the soil should be maintained by some system of green-manure cropping. Such leguminous crops as alfalfa, clover, soybeans, cowpeas, and vetch are good sources of organic matter. A green-manure crop that is well adapted to the locality should be grown. The legumes are especially desirable for lettuce production since, when properly inoculated with nitrogen-fixing bacteria, they increase the nitrogen supply in addition to building humus. The rate of decomposition of green-manure crops depends on several factors, the most important of which are the stage of maturity of the crop and the moisture and temperature of the soil. Mature woody stems require more time for decay than immature plant materials. However, the amount of lasting humus-building material increases with the age and maturity of the plant.

If rye, oats, or some other nonlegume is used as a manure crop, more nitrogen will be required in fertilizing for the lettuce crop than if a well-inoculated legume is used. An application of 200 or 300 pounds of nitrate of soda or sulfate of ammonia per acre at the time the nonlegume crop is plowed under will aid in the decomposition of the plant material and add to the nitrogen supply of the soil. The rate of decomposition of organic materials is much more rapid at high than at low temperature, and the moisture supply must be relatively high for rapid decay.

USE OF COMMERCIAL FERTILIZERS

For the growing of lettuce most soils require the application of some of the nutritional elements in the form of commercial fertilizer, unless a very heavy application of manure high in the fertilizing elements has been used.

As indicated previously, no recommendations as to the amount and composition of commercial fertilizer for use on every field can be given here. Each piece of land has its specific requirements that must

be determined largely by experience. Commercial fertilizers may be required in the form of single elements or in combination of two or more.

Of the three elements, nitrogen, phosphorus, and potassium, usually applied in fertilizers, nitrogen is in general most likely to be needed for lettuce. This is especially true in the western irrigated districts, where many soils are naturally well supplied with phosphorus and potash but are low in nitrogen. Nitrogen can be applied in either the inorganic or the organic form. The commonest forms of inorganic nitrogen are nitrate of soda and sulfate of ammonia. Where the soil reaction is near or above neutral, as in many parts of the West, sulfate of ammonia can be used to good advantage. In many parts of the East the soil reaction is on the acid side, and sulfate of ammonia should be used sparingly unless lime is added to maintain the proper soil reaction.

Nitrogen in the organic form may be obtained from fish scrap, dried blood, cottonseed meal, tankage, and related materials. These substances must undergo decomposition in the soil before their nitrogen becomes available to the plant. In such form the nitrogen becomes available slowly and does not cause the excessively rapid growth that may result from a heavy application of inorganic nitrogen when conditions are optimum for growth. When the temperature is low, nitrogen becomes available from organic materials in the soil at a very slow rate or not at all; therefore during the cool seasons it is best to apply part or all of the nitrogen in the inorganic form.

In some of the large producing centers of Arizona and California nitrogen in the form of anhydrous ammonia is applied to the lettuce crop through irrigation water. This requires very accurate measurements of the rate of flow of the water and of the ammonia gas. This method of applying nitrogen is adaptable only to irrigated sections where the measurement and flow of water can be well controlled. The application is made under the supervision of employees of the company supplying the compressed gas.

Fertilizer experiments indicate that in many localities lettuce responds favorably to fairly high applications of phosphorus. Probably the best source of phosphorus is superphosphate. Bonemeal is a good source of phosphorus. However, it is in a form not immediately available to the plant and should not be used where immediate results are desired. Raw ground phosphate rock is generally unsuitable as a source of phosphate for lettuce because of its slow rate of availability. There is some evidence that very large amounts of available phosphorus may tend to encourage premature seed-stem development, especially where the nitrogen is low, suggesting that very large amounts of available phosphate should be avoided where the crop is to mature during fairly warm weather.

Experiments indicate that lettuce does not require large amounts of potassium and may even be injured by too much of this element. While potassium is essential for growth of the lettuce plant large amounts should not be applied unless local experience indicates a need for it.

Lettuce land is usually fertilized with nitrogen, phosphorus, and potassium in the proportions and amounts found by experience to be best for local conditions. A complete fertilizer containing 5 percent nitrogen, 8 percent phosphorus, and 5 percent potash is a good standard formula. In using mixed fertilizers the grower should consider

the sources and availability of the elements, especially the nitrogen. The composition should be varied as local conditions require. Frequently as much as a ton per acre is applied where the soil is known to be low in the fertilizing elements. When such large amounts are used the fertilizer should be applied and thoroughly incorporated with the soil well in advance of planting time or injury to the young plants may result. As indicated on page 15, during cool weather much of the nitrogen should be applied in the immediately available inorganic form. Lettuce is generally side-dressed with 100 pounds or more of nitrate of soda or sulfate of ammonia after the plants have been blocked and thinned or after the crop has become well established when it is grown from transplanted plants. The application of nitrogen as a side dressing late in the development of the plant may cause too vigorous growth, resulting in large loose heads or an undesirable ribbiness.

In some lettuce regions, the South Atlantic one in particular, lettuce sometimes fails to make a satisfactory crop because certain elements like magnesium, copper, and boron, are deficient in the soil. The symptoms in the lettuce plant that indicate such deficiencies are not easy for the average grower to recognize, and methods of determining the elements needed are complicated. Since these deficiencies are often somewhat local in distribution and the methods of determination are complicated, it is generally necessary for the grower to depend upon the State or local crop or soil specialists for assistance in determining the deficient elements and the amounts required.

PREPARATION OF THE SOIL

Good drainage is essential in any soil to be used for the production of lettuce. If the land does not already have good drainage the provision of a drainage system is the first operation to be performed. Drainage may be accomplished by either an open trench or underground tile, the system used being determined according to local conditions. For information on drainage systems and their construction the reader is referred to Farmers' Bulletin 1606, Farm Drainage.

The preparation of the soil for the planting and growing of lettuce is much the same as for the growing of other vegetables. Thorough preparation is essential and will do much to assure a good stand of plants and reduce the amount of labor needed after the crop is planted. The operations required consist of plowing, disking or harrowing, leveling or floating, and ridging or bedding where the crop is to be grown on beds or ridges.

The implements and the methods of preparing the soil vary in different localities. Those employed by successful growers in the locality should be used as a guide in such matters.

Soil for lettuce should be plowed deep wherever practicable. Organic matter needs to be incorporated to a depth of 8 inches or more. Land for lettuce growing, especially the heavy soils, should never be plowed when wet. Lettuce seed is small and requires a finely prepared soil to assure germination. Land plowed when wet can never be put into the best condition as a seedbed for lettuce, and the bad physical condition resulting from plowing soil while too wet may cause trouble throughout the season.

Where a cover crop, sod, or heavy application of manure is to be plowed under, plowing should be done well in advance of the planting season to permit thorough decomposition of the organic materials.

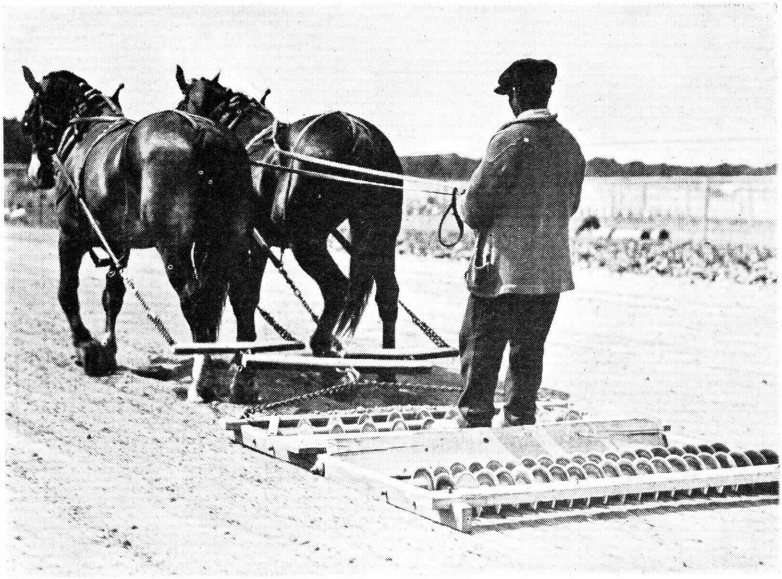
In the Northern States plowing is often done in the fall, and the land is left rough during the winter if it is not subject to erosion. Fall plowing is especially desirable for heavy land that is slow to dry in the spring or has a tendency to become cloddy if worked while wet. The action of freezing and thawing on plowed land during the winter leaves it in a mellow condition, and a fine seedbed can then be obtained in early spring by disking and dragging or by working with other suitable implements.

The mellowing of the soil through exposure to frost and other benefits derived from fall plowing in the North are not obtained farther south; therefore, most of the land is spring-plowed.

Whether the land has been fall- or spring-plowed, the surface soil to a depth of several inches should be thoroughly worked with a disk, harrow, or other implements until it is in a good condition for a seedbed. The implements required to put the surface in good condition depend on the texture and condition of the soil. Implements having cutting edges such as disks and Meeker harrows usually leave the surface in better condition for the operation of seeders than such a non-cutting implement as a spike-tooth harrow. A spike-tooth harrow or similar implement has a tendency to drag clods, stones, and unrotted organic matter to the surface, and these may interfere with the planting shoe of the seeder and prevent proper covering of the seed. The final operation in preparing the seedbed should be done with an implement that will leave the surface as free of clods and trashy organic materials as possible. The Meeker harrow (fig. 8) is well adapted for fitting the surface soil for planting when flat culture is to be used.

In the irrigated sections of the West leveling is an important operation in the preparation of land, in order to assure the proper flow of water in the furrows. However, leveling to the extent of moving soil to a depth of more than a few inches is undesirable in most parts of

Figure 8.—Meeker harrow, useful for finishing the preparation of the soil before planting lettuce.



the East because it leaves unproductive spots where the surface soil has been removed. Such spots may require special fertilization and heavy applications of organic matter for several years before they are again productive.

Where the lettuce crop is to be grown on ridges or beds these should be thrown up and the top leveled with a light drag or roller before planting.

IMPORTANCE OF GOOD SEED

Very little lettuce seed is imported. Until recently California produced nearly all the lettuce-seed crop, but at present considerable lettuce seed is being grown in Arizona and Idaho.

Lettuce seed can be kept viable for a long period if stored where it is cool and dry. It rapidly loses its ability to germinate if kept under warm, moist conditions. The percentage of germination of lettuce seed generally declines rapidly after 2 years in warm, humid localities; low moisture content is essential if the viability of lettuce seed is to be maintained. Old lettuce seed should not be used for planting without first being tested for germination.

The seed of most varieties of lettuce germinate poorly if planted soon after harvesting, especially if the soil temperature is above 70° F. Some lettuce seed requires a few months of afterripening before it can be germinated readily under normal conditions. At temperatures above 70° germination can be greatly increased by immersing the seed before they are planted in a one-half of 1 percent solution of thiourea in a shallow vessel for 8 to 12 hours. The effectiveness of the treatment declines rapidly as the soaking period is decreased below 8 hours. More than 12 hours in the solution may result in the loss of some seed through germination if the temperature is near the optimum (60° to 65°). Only enough solution to cover the seed should be used. The temperature during the treatment should be between 60° and 70°. Treated seed should be washed in tap water, spread out thinly, and thoroughly dried. The germination of dormant lettuce seed can be greatly increased, and nearly all lettuce seed can be germinated at a higher temperature after the thiourea treatment. The resulting stimulation persists for some time.

FIGURE 9.—Single-row bed system for horse cultivation.

FIGURE 10.—Double-row planting system on slight beds.

On account of the uncertainty of the germination of lettuce seed as a result of dormancy or age, it is advisable to test its germination before planting, especially when large acreages and heavy expenses are involved.

SEEDING IN PLACE

Many planting systems have been used with success in the various lettuce-producing districts of the country, but not all are equally adapted to any particular locality. A planting system should be followed that has been proved by years of experience to be adapted to local conditions.

Nearly all the lettuce produced in the West and a considerable part of that in the East is grown from seed planted directly in the field with mechanical seeders. Usually about 2 pounds of seed is used per acre. If the seed is good and soil conditions are favorable for germination, a satisfactory stand of plants may be obtained with the use of as little as a pound per acre. The lighter rate of planting saves considerable labor in blocking and thinning. However, if there is reason to believe that the seed does not have a high percentage of germination or if soil conditions are not favorable for germination, a heavier rate of seeding should be used to assure a satisfactory stand.

Systems of planting vary from single- to six-row beds. Most of the commercial crop is now grown with or without ridge in single- (fig. 9) or in two-row beds (fig. 10). Wide beds of four to six rows (fig. 11) were formerly used quite extensively in some of the Eastern States for growing the Boston type of butterhead lettuce. With the shift from the Boston to the New York, or crisphead, type, the system of planting throughout most of the Eastern States has changed to either the single- or the two-row bed. The single-row system of planting varies among the different districts. In some the single rows are planted on ridges (fig. 9) of varying heights, while in others flat culture in single rows is the practice. Ridging is desirable where heavy rains occur during the growing season and where the soil is of such a character that it does not dry quickly under the plants after

FIGURE 11.—Lettuce planted on 6-foot beds.

rains. Some of the loss due to decay of the lower leaves may be avoided by growing the crop on narrow ridges. Ridging is not desirable on well-drained land or on light soils as under these conditions it may cause the crop to suffer more during periods of limited moisture supply than it would under flat culture.

The two-row bed is the most widely used system throughout the large districts of California, Arizona, and other Western States. Other systems are used, but they are not generally considered as satisfactory. The height of the bed is determined by local conditions of soil type, drainage, and alkali content of the soil.

In planting lettuce seed directly in the field with mechanical seeders it is important that the machine be properly adjusted to drop the seed regularly, accurately, and at the proper depth so that it will be thoroughly covered. Lettuce seed should be planted as shallow as possible and yet be completely covered. The depth of planting is governed by the texture of the soil and its water-holding capacity. The seed may be covered deeper in light than in heavy soil. Seed should be planted a little deeper in soil that has a tendency to dry rapidly at the surface than in soil in which adequate moisture for germination can be assured. Only under exceptional conditions should lettuce seed be covered to a depth of more than one-half inch. If sufficient moisture for germination can be assured, a depth of a quarter of an inch is enough.

Planting distances both between rows and between plants in the row differ, depending upon the varieties grown and the system of cultivation and irrigation used. In most cases the distance between rows in the single-row system should be not less than 18 inches. Varieties that produce small heads, as most of those of the butterhead type, can be grown in rows closer together than the large crisphead varieties like New York and the Imperials. If small-headed varieties are grown and all of the work is to be done by hand, the rows may be as close as 12 to 15 inches. However, crowding either between rows or within the row is undesirable. The chances for loss from diseases are much greater where too-close planting causes poor ventilation around the plants. If the crop is to be cultivated by horse-drawn cultivators the distance between rows should not be less than 2 feet.

In the western irrigated sections, where the crop is grown by the two-row-bed system, the standard distances are 14 inches between rows on 20-inch beds with 22 inches between beds, or a total of 42 inches from center to center of the beds.

Where the wide-bed system is still used, it is a general practice to plant six rows on a 6- or 7-foot bed with a 12- to 15-inch space between beds.

In districts where the crop is grown under irrigation by the furrow method it is desirable to irrigate the land in advance so as to allow the soil to settle before planting the seed. In the nonirrigated districts it is preferable to plant after a rain rather than just before. In soils that tend to puddle when wet, germination may be adversely affected by the crust that forms on the surface after a rain.

Successful head-lettuce production depends upon bringing the crop to maturity at a time when temperature conditions are favorable. In eastern United States the spring crop reaches maturity at a time when the temperature is becoming unfavorably high, and late-planted fields often fail to head but shoot to seed prematurely. Hot weather at maturity increases the loss from tipburn and slime (soft rots).

Varieties of head lettuce differ in their adaptation, especially to temperature. Such varieties as Imperial D and Imperial 615 have a tendency to become oversized and to form soft, ribby heads if grown during warm weather. These varieties are best adapted for growing during the cooler months, since their naturally large size gives a satisfactory commercial head when many other varieties tend to produce undersized heads. Some varieties like Imperial 847 have a wide range of adaptation and are grown over a wider area and during a greater part of the year. There are also great varietal differences in susceptibility to diseases.

In the large commercial growing districts of California and Arizona these differences in varietal response to weather conditions have led to a well-established schedule of planting dates for the different varieties. That is, the different varieties are planted on such dates that they will develop during the seasonal conditions to which they are best adapted. A schedule of planting dates used in these districts is given in table 1.

TABLE 1.—*Planting dates for the important lettuce varieties in the commercial growing districts of California and Arizona*

District and variety	Planting dates	Period to maturity
		Days
Imperial Valley, Calif.:		
Imperial 152	September 20 to 25	90 to 100
Imperial 615	September 25 to November 1	90 to 100
Imperial 615	After November 1	85 to 95
Salinas-Watsonville, Calif.:		
Imperial 850	March 25 to June 1	65 to 85
Imperial 847	March 25 to July 15	65 to 85
Imperial 44	June 1 to July 15	65 to 85
Imperial D	July 25 to September 1	75 to 90
Imperial 152	July 15	65 to 85
Imperial 615	November 2 to March 20	100 to 145
Salt River Valley, Ariz.:		
Imperial 152	September 3 to 15	75 to 95
Imperial 615	October 20 to November 5	110 to 150
Yuma, Ariz.:		
Imperial 847	September 1	90 to 120
Imperial 152	do	90 to 120
Imperial 44	do	90 to 120
Imperial 615	September 20 to November 15	100 to 145

The lack of adapted varieties and the limited growing season have prevented the establishment of such a well-organized planting schedule

for the eastern lettuce districts. As better adapted varieties are developed and introduced, a similar planting schedule may be developed for the Eastern States.

GROWING PLANTS FOR TRANSPLANTING

In order to reduce the danger of crop failure due to unfavorably high temperature at heading time a large part of the commercial head-lettuce crop in the Eastern States is started early in protected beds and transplanted to the fields. This method of culture is practiced in the lettuce-growing districts of Florida, South Carolina, North Carolina, Virginia, New Jersey, and to a lesser extent in other parts of the East wherever the last killing frost in the spring is soon followed by temperatures too high for lettuce. By having bed-grown plants of good size ready for transplanting into the field as soon as danger from killing frost is past, it is possible to mature the crop before temperatures become too high. In certain localities some planting of seed in the field is also done as soon as soil and weather conditions permit the working of the soil and the operation of mechanical seeders. In some seasons these field-seeded plantings mature a satisfactory crop before the hot weather comes, but in the average season they cannot be depended upon in the areas mentioned.

With some of the recently introduced varieties of head lettuce a satisfactory early crop can be produced in many of the Eastern States if hotbeds or coldframes are used for starting the plants.

In the South Atlantic States most of the plants for transplanting are grown in beds in much the same manner as tobacco plants are grown in the tobacco-growing districts of the South. These beds receive very little protection other than a covering of thin muslin. The beds are frequently protected from prevailing winds by selecting a location on the sunny side of a woods or thicket. A bed of this kind 100 by 10 feet should provide enough plants to set an acre or more.

Farther north, in New Jersey for example, lettuce seedlings for field planting are grown in sash-covered coldframes. A standard sash 3 by 6 feet is in general use. A 50-sash bed should provide plants to set an acre or more.

The soil to be used for growing lettuce seedlings for transplanting should be well fertilized. About 4 pounds of a 5–8–5, a 5–8–7, or a complete commercial fertilizer of similar composition should be applied for each 100 square feet of bed and should be thoroughly incorporated with the soil some time before planting.

A quarter of a pound of good seed should produce enough seedlings to set an acre where the plants are grown in well-prepared beds and properly cared for. The seed should be planted thinly to assure large sturdy plants. Crowding in the beds increases the danger from loss through damping-off and other diseases; furthermore, plants that have been crowded in the beds are greatly inferior to those that have had sufficient space to develop properly. The harmful effects of crowding become worse if it is necessary to hold the plants in the beds beyond the normal transplanting date because of unfavorable soil or weather conditions that delay transplanting to the field. The importance of this should not be overlooked.

Great care must be exercised in watering and ventilating the plant beds to prevent loss from damping-off. Where past experience indicates that such loss may be serious, lettuce seed should be treated before planting (p. 27).

Where damping-off in the seedbeds has caused serious loss of plants it is advisable to change the soil, to locate the beds on new soil on which no lettuce has been grown for several years, or to sterilize the bed with chloropicrin or formaldehyde (p. 27).

In most of the districts where lettuce is produced from bed-grown plants it is necessary to transplant the seedlings to the field while temperatures are still relatively low. Temperatures near or below freezing often occur after the plants have been set in the field. Soil temperatures are frequently so low for some time after setting that the transplanted seedlings fail to obtain sufficient nitrogen for satisfactory growth. The plants often become yellowish green from lack of nitrogen and may be badly stunted before the soil becomes warm enough for the nitrogen to become available. When lettuce seedlings are to be moved from the plant beds to the field before the soil temperatures in the field are high enough for normal growth the grower can do much to assist the plants through this period by applying available nitrogen about a week before removing them from the beds. Nitrate of soda alone or nitrate of soda and sulfate of ammonia in equal proportions may be applied at the rate of about one-half pound per 100 square feet of bed. If weather conditions should make it necessary to hold the plants in the bed for several days after applying the nitrogen, they may become too succulent and suffer from crowding. For this reason only such portion of the beds should be treated at one time as the grower has reasonable assurance can be transplanted to the field within a week or 10 days.

BLOCKING AND THINNING

Thinning is the most laborious and expensive operation in the production of lettuce. This task is eliminated where the crop is grown from transplanted plants. Lettuce seeded in place whether by seeders or by hand requires blocking and thinning. Blocking with a hoe or a blocking machine removes from the row all the plants except small clusters at regular intervals of 10 to 16 inches. This is usually done about 10 days to 2 weeks after planting. A few days later all but one of the plants are removed from each of the clusters left in the blocking operation. This is largely hand work. Neither blocking nor thinning should be delayed until the plants are permitted to suffer from crowding. Frequently the sturdier plants removed in blocking are saved and set in parts of the field where the stand is poor or in other fields. In the large producing sections of the West most of the blocking and thinning is done under contract on an acre basis.

The distance between plants in the row should be determined largely by the size of the plant produced, the particular variety, and the fertility of the soil. Small varieties should be thinned to about 10 inches between plants; large varieties like New York should be left from 12 to 16 inches apart in the row. The spacing should be wider on very fertile land.

It is very important in thinning that only one plant be left in a place; where two or more are left by careless thinners, good commercial heads will not develop. Care should be exercised to avoid moving too much soil away from the plants in the blocking and thinning operations. It is often necessary to replace the soil around the plants after completion of the thinning operations. Carelessness and rough handling of the plants in doing this work may severely check development and delay maturity.

CULTIVATION

Cultivation of lettuce is done primarily to destroy weeds, but in the irrigated areas it is also important in preventing the formation of a gumbo crust in the bottom of the irrigation furrow. In the nonirrigated areas thorough cultivation of the surface should follow every heavy rain, to prevent the formation of a surface crust. All cultivation of lettuce should be shallow, as the plant has a shallow root system and is a poor forager. Deep tillage may destroy many of the feeding rootlets and check the plant's development. Cultivation of any kind late in the season should be very carefully done to avoid serious injury to the crop.

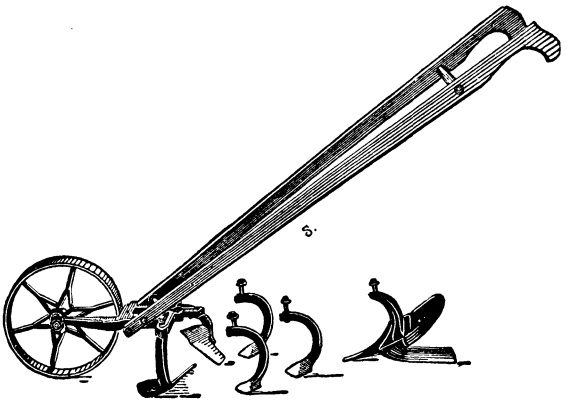


Figure 12.—Wheel hoe frequently used for cultivating lettuce.

Careful root pruning by cultivating equipment may be used to advantage in checking too rapid a growth rate caused by abundant moisture and favorable temperature where the soil fertility is high. This practice should be employed only by experienced growers and then only when there is reasonable certainty that the crop will be lost through overdevelopment if the growth rate is not checked.

The rows may be planted close together if the cultivation is to be done with hand and wheel hoes (fig. 12). Small garden tractors (fig. 13) are now in general use in the planting and cultivation of lettuce. If weeding and cultivating are to be done with horse-drawn implements the rows should be at least 2 feet apart. Some hand hoeing is always necessary in destroying weeds close to the plants. The lettuce field should be as free of weeds as possible by the time the heads have begun to form so that a minimum of cultivation will be required during the heading period.

Cultivating and weeding implements that are best adapted to the system of planting followed in the locality should be used.

The number of cultivations required to grow a crop of lettuce varies with the character of the soil, with the weather, and, most important of all, with the amount and kinds of weed seed in the soil and the thoroughness with which weeds are destroyed at each cultivation. Two or three cultivations and one or two hand hoeings are enough under average conditions. To be most effective in destroying weeds, cultivation should be done while the weeds are still very small, the soil in good condition for working, and the sun bright.

Many weeds may not be killed and may take root again if the soil is wet or if cultivation is followed immediately by a rain. It may not always be possible to arrange or control conditions so that cultivation can be done at the most effective time, but an effort should be made to take advantage of favorable weather conditions.

The amount of work and expense required to destroy large weeds may be many times that required to control them while they are small. Efficient weed control depends upon destroying the weeds while they are small.

IRRIGATION

Lettuce requires a constant and fairly high soil moisture from planting to harvest. Wide fluctuation in soil moisture is undesirable at any time and may cause great damage to the crop in the late stages of development. The soil should be wet enough for only a short time after a rain or irrigation to form a ball when squeezed in the hand, but the moisture content of the soil should never go so low that more than the surface becomes dry.

Where irrigation water is applied from a sprinkling system during warm weather it is best to apply the water in the early morning, while the plants are cool and before they reach the wilting point. Great loss from tipburn and slime (soft rots) may result from careless irrigation of nearly mature lettuce by a sprinkler system during the warmest hours of the day. Rains during hot weather may likewise cause damage to the leaves.

In districts having rainfall during growth of a lettuce crop, the time and amount of irrigation should be carefully studied with relation to weather forecasts and amount of the soil moisture. The most

Figure 13.—Small garden tractor such as is used for cultivating lettuce.

expert growers keep a careful watch on both the weather and their lettuce crop, applying only enough water to carry the plants through until it rains. During continued dry weather irrigations usually are needed about once a week.

Lettuce grown in the eastern or humid regions requires from 5 to 8 inches of rainfall or its equivalent in irrigation to produce a spring crop, the amount depending somewhat upon the character of the soil, the percentage of cloudy weather, and the prevalence of winds. The ordinary overhead or spray system will distribute approximately 60 gallons of water per minute over an acre, thus requiring about a 4-hour watering to apply one-half inch of water over the entire surface, or sufficient to fairly saturate the soil.

In the western lettuce-growing districts almost the entire crop is grown under irrigation. The rainfall in most of these districts is very low; consequently the soil moisture is largely within the control of the grower. Under such conditions it is essential that the grower know the moisture requirements of the lettuce plant and control the irrigation accordingly. Although practices in the West vary with the locality and character of the soil, most of the irrigation is by the open-furrow method. Considerable experience is required to use this system successfully. Skill in the control of the flow of water and knowledge of the amount and time to apply water are learned only through experience. There are two periods in the development of lettuce when even slightly excessive amounts of water are likely to be injurious to the crop. The first is the early stage, when too much water in the soil may cause the development of a shallow and limited root system. The second critical period is that just preceding maturity—a too high soil-moisture content at this time may cause a too rapid rate of growth, with soft or puffy heads resulting.

In the East, where there are few irrigation systems, the lettuce crop frequently suffers from drought. Where suitable water for irrigation is available, there is little doubt that the installation of an appropriate irrigation system could be made a profitable investment in many of the lettuce districts. This is becoming more often true with the development and introduction of new varieties that can be grown in the East.

DISEASES OF LETTUCE

The most important diseases of lettuce are damping-off, tipburn, downy mildew, brown blight, drop, or sclerotiniose, bottom rot, and aster yellows. Losses generally of minor local importance are caused by mosaic, wilt, big vein, anthracnose, and other leaf spots. Many lettuce diseases can be controlled only by rotation, sanitation, or the use of resistant varieties.

In using poisonous chemicals to control diseases for which they are effective, care should be taken, as recommended for insecticides (p. 33).

DAMPING-OFF

The term "damping-off" is used to indicate either the decay of the seed or seedlings in the soil or the collapse and death of small seedlings as a result of the destruction of the tissues of the stem near the soil surface. This condition may be caused by any one of a number of fungi common in the soil. The disease may become evident as soon

as the plants have emerged above ground and may continue to cause destruction until the stems have formed woody tissues. Occasionally damping-off may cause some loss of plants in the field, but it is primarily a disease in the seedbeds. It often appears in small localized spots but may spread rapidly and destroy an entire bed if the ventilation is poor and the bed is kept too damp. Avoiding excessive moisture and providing good ventilation will help to reduce the chances for the development of damping-off; much can be done also by using a light sandy soil that dries out rapidly, especially for the surface covering of the beds.

Where damping-off has caused serious loss of plants in the seedbeds it is advisable to change the soil or to move the beds to a new location. If it is necessary to use soil where damping-off organisms are known to be present, the soil should be sterilized with chloropicrin or formaldehyde.

Chloropicrin (tear gas) has been found to give good results as a soil disinfectant. The chemical as sold under a trade name comes in gas cylinders under pressure and is applied by means of devices designed by the manufacturers for injecting it into the soil. Unless one has had experience in the use of chloropicrin, a county agent or someone experienced in handling it should be consulted before undertaking to use it.

Care should be taken that none of the chemical comes in contact with the clothing, skin, and especially the eyes, as it is irritating. It is very injurious to plants.

In using chloropicrin it is important that the soil be loose, friable, and fairly moist and that the temperature be between 60° and 85° F. for most efficient sterilization. The chemical is applied by injecting about 2 cubic centimeters of the liquid at a depth of 5 or 6 inches at intervals of about 10 inches. After the application the holes should be filled immediately and the soil pressed down and wet to a depth of about 1 inch to form a water seal, thus preventing the escape of the gas. Where possible it is advisable to cover the soil with paper or some other suitable cover. The seal should be maintained for about 3 days. The treated soil should not be used as a seedbed until the gas has escaped, as it is very injurious to plants. The time required depends on the temperature and moisture content of the soil. Working the soil to a depth of several inches hastens the escape of the gas.

Formaldehyde is frequently employed as a soil disinfectant. The commercial product generally available is a 40-percent solution sold as formalin. As a soil disinfectant, formalin should be diluted in the proportion of 1 gallon to 30 gallons of water and this applied at the rate of 1 quart per square foot of soil. The soil should be loose, friable, and fairly moist. After applying the solution, the soil should be given a thorough wetting and covered for about 2 days. The cover should then be removed and the soil permitted to dry. This may require 2 weeks or longer, depending upon the temperature. It is very important that most of the moisture be removed from the soil before it is used as a seedbed. Water tends to hold the formaldehyde in the soil and serious injury to germinating seed may result if the soil is not sufficiently dried out after the treatment.

The use of chemical dusts is effective in preventing the decay of the seed and the killing of young seedlings before they emerge from the soil. The following materials have been found to give protection

against damping-off when used at the rates indicated: Red copper oxide (Cuprocide) or zinc oxide at the rate of 2 percent by weight of seed or organic mercury dust (Semesan) at the rate of a level teaspoonful per pound or one-half ounce to 15 pounds of seed. The seed with the proper amount of the protectant should be placed in a tightly closed container and shaken 3 or 4 minutes, or until each seed is thoroughly coated. Any excess dust may be screened off and saved for other treatments. The seed is then ready to plant.

TIPBURN

Tipburn is the most widespread of all diseases common to lettuce, occurring in every lettuce-growing district of the country under both field and greenhouse conditions. It is a nonparasitic malady most prevalent during periods of high temperature. Plants in a succulent condition resulting from rapid growth are more susceptible to tipburn than those less succulent. As far as they are within the grower's control, conditions that stimulate rapid, watery growth should be avoided, especially during the late stages. A lettuce crop grown with a uniform moisture supply at a fairly high level is more likely to escape injury by tipburn than one in which the growth rate of the plants is irregular because of fluctuating moisture supply. Excessive fertilization, especially with readily available forms of nitrogen, should be avoided where the crop is to mature during warm weather.

Tipburn is characterized by the breaking down of the tissues of the actively growing leaves at their margins. The first evidence of the break-down is often the development of small brown or black spots in the tissues near the larger veins. As the break-down advances the marginal area dies. The dying seldom extends more than a half inch from the edge of the leaf, but in severe cases a discoloration of the large veins may extend for some distance.

The greatest loss from tipburn results from secondary decay caused by certain fungi and bacteria that infect the dead tipburned areas.

Since tipburn results from conditions largely beyond the grower's control, the only promising method of combating the disease is the development of varieties better able to withstand the environmental conditions that cause it. Much progress has been made by the United States Department of Agriculture and the State experiment stations in breeding varieties resistant to tipburn.

DOWNY MILDEW

Downy mildew is widespread on lettuce but is probably more common under field conditions in some of the Western States than in most of the lettuce-growing districts of the East. It sometimes causes trouble where lettuce is grown under glass. The disease, caused by the fungus *Bremia lactucae* Regel, first makes its appearance as light-green or yellowish areas on the upper surface of the leaves, then the downy white growth of the causal organism soon appears on the under side of the leaf, opposite the discolored spots. As the disease progresses, the affected areas turn brown. Downy mildew is most likely to develop during periods of damp, foggy weather when temperatures are only moderately warm.

The most effective control measure is to grow resistant varieties. The United States Department of Agriculture and the California

Agricultural Experiment Station have developed a number of crisphead varieties that are very resistant to certain strains of the downy mildew organism. Among the best of these are Imperial 152, Imperial 847, Imperial 615, and Imperial 850. However, none of these are resistant to all strains of downy mildew. A variety that is highly resistant in one particular season or locality may succumb to the disease in another season or locality owing to the presence of different physiologic forms of the mildew.

Downy mildew also attacks wild lettuce and perhaps some other closely related species. Wild lettuce near the lettuce field or greenhouse should be eradicated as a precautionary measure. Although not generally practical under field conditions, the application of a 2–4–50 bordeaux mixture (or a 20–80 copper-lime dust) may be used to check the disease, particularly in plant beds and greenhouses.

BROWN BLIGHT

Brown blight is apparently soil-borne. This disease was at one time very prevalent on and destructive to lettuce in California and Arizona, but it has never been reported as occurring in other parts of the country. The disease causes small, yellow, discolored spots on the younger leaves, and irregular brown blotches, streaks, and dead areas on the older ones. Plants are attacked in all stages of growth after they have reached the five- or six-leaf stage. So far as is known, lettuce is the only species of plants attacked by brown blight.

The causal agent may remain active in the soil for several years, even though the land is planted to crops other than lettuce.

The loss resulting from brown blight has been almost eliminated by new varieties resistant to the disease, developed by the United States Department of Agriculture and the California Agricultural Experiment Station. Imperial 152, Imperial 847, Imperial 850, Imperial 615, and Imperial D are all standard commercial varieties that are resistant to brown blight. There is no known control other than the growing of resistant varieties.

DROP, OR SCLEROTINIOSE

Drop of lettuce is caused by certain closely related species of fungi (*Sclerotinia sclerotiorum* (Lib.) DBy, and *S. minor* Jagger). Very young plants affected by the disease wilt and die rapidly. Symptoms of the disease in older plants vary, depending upon its rate of development. In some cases the rate of advance is very rapid and the entire plant may wilt down into a slimy mass; if the rate is slower the symptoms may first be recognized by the wilting of the outer leaves. Examination of the plant at the soil surface reveals water-soaked spots on the stem near the soil line and similar ones on the petioles and lower parts of the outer leaves. As the disease progresses, the leaves, starting with the outer ones and continuing inward, droop and finally fall to the ground. It is the appearance of the plant in these late stages that has given the name drop to this disease (fig. 14). Sometimes the diseased stems show a pink, reddish, or brown discoloration. If soil moisture becomes low and is accompanied by low humidity after infection the advance of the disease may be retarded or checked altogether after only a few leaves and the outer tissues of the stem have become infected. In such cases the plant may survive

FIGURE 14.—Lettuce plants destroyed by drop.

and continue to grow at a very much reduced rate for a considerable time before succumbing.

The organisms causing drop are widespread throughout the United States and may attack a great many other plants besides lettuce. These organisms are capable of causing loss in transit, in storage, and on the market as well as in the field. They produce reproductive bodies that may live for long periods on diseased plant tissues in the soil.

In greenhouses it is possible to control drop by thorough sterilization of the soil by steam, chloropicrin (p. 27), or formaldehyde (p. 27). If only a few plants are affected, spread of the disease may be at least partially controlled by removing them carefully. In the field, soil sterilization is impractical but sanitary measures afford some control.

Since the disease develops most rapidly under cool, moist conditions the use of well-drained soil that dries out rapidly on the surface will reduce the chances for infection. The plants should not be crowded, since the fungus may spread from plant to plant. Weeds should be held down, as some of these may be hosts and weed growth may reduce ventilation and prevent surface drying.

No lettuce varieties are known to be immune or resistant to drop.

BOTTOM ROT

Although not generally widespread, bottom rot is highly destructive to lettuce in some localities nearly every season. It is caused by *Rhizoctonia solani* Kuehn, one of the organisms that commonly cause damping-off. The plants may be attacked at nearly all stages of growth, and the disease may be present throughout the growing season.

Bottom rot is at first characterized by rust-colored sunken lesions on the petioles and midribs and a slimy rot on the blades of the bottom leaves of the plant that touch the soil. As the disease advances, it spreads from the lower leaves upward until the entire head becomes a slimy mass.

The bottom rot organism enters the plant from the soil through the lower leaves that are in contact with it. Varieties that have an upright habit of growth and little contact with the soil, the cos varieties in particular, are less subject to bottom rot than those like Big Boston in which the lower leaves spread out in contact with the soil.

The causal organism requires a moderately high temperature and abundant moisture for its development. Frequently a severe epidemic of bottom rot may develop during a period of warm, damp weather and then disappear if a period of dry weather follows.

Rotation of lettuce with other crops such as sweet corn, onions, and others not attacked by the causal organism is the only practical means of control, since field sterilization is impractical. Only well-drained land should be planted to Big Boston and other low-growing varieties in districts where bottom rot occurs.

ASTER YELLOWS

Within the last few years, aster yellows has become a very serious disease of lettuce in some of the important lettuce-growing districts. The greatest loss has been in the Northeastern States. The disease is caused by a virus that produces a similar disease in many other species of plants. The name "aster yellows" was given to the disease because of its having first been found and identified on asters.

FIGURE 15.—Seed stems of (*A*) a plant affected with aster yellows and (*B*) a normal plant.

The virus causing the disease is spread from plant to plant by insects feeding upon them. So far as is known, only one species of the leafhopper is capable of spreading the virus. The insects first become carriers of the virus by feeding upon diseased plants. Lettuce fields are generally infected by leafhoppers that have overwintered on diseased wild plants.

The disease is characterized by a yellowing of the

leaves and flower parts (fig. 15). In young plants the central leaves and those actively growing are the first to show the characteristic yellowing. In older plants one side may show yellowing while the rest of the plant is still green. In plants that have developed a seed stem before being inoculated, some of the laterals may show the disease while others may remain healthy. If the terminal growing point of the stem is inoculated, the disease spreads through the entire plant and all the flowers may show the symptoms of the disease. In diseased flowers the petals become thickened and abnormally enlarged and take on a greenish color instead of the normal yellow.

There is no practical control for aster yellows other than destroying the insect carriers.

INSECT ENEMIES OF LETTUCE [1]

Lettuce is subject to attack by several kinds of insects, the principal ones being cutworms, the cabbage looper, wireworms, the corn earworm, and aphids. Attacks by these insects, with the possible exception of cutworms, are, however, not general. Cutworms may damage lettuce in almost every area where the crop is grown, whereas injury to lettuce by wireworms is localized, as is that by the corn earworm. The cabbage looper is an annual pest in some districts of Arizona and California and causes periodic damage to lettuce in Florida. Aphid infestations are usually localized but may occur in any area in which lettuce is grown.

CUTWORMS

Cutworms are particularly destructive to lettuce seedlings and may cause considerable loss as the seedlings appear above ground or when plants are set in the field. Some species of cutworms overwinter in the soil, and as soon as the weather becomes favorable in the spring they are ready to attack the early planted crop. Late-season crops of lettuce may be damaged by cutworms that passed the winter in the egg stage. Cutworms feed, for the most part, at night, spending the day inactive just below the surface of the soil. They are unusually destructive because they prefer to feed by cutting into the stem of the plant a short distance above the ground. When the crop is reaching maturity, however, they may feed on the leaves and burrow into the developing heads.

On the young crop, cutworms can be controlled by the timely use of a poisoned bait, prepared as follows: Dry bran, 1 peck or 5 pounds; sodium fluosilicate, ¼ of a pound; water, 3 or 4 quarts; or, for larger quantities: bran, 25 pounds; sodium fluosilicate, 1 pound; water, 15 to 20 quarts. Paris green or white arsenic may be substituted for the sodium fluosilicate as the poison in this bait; but because of conditions brought about by the war these materials may not be so readily obtainable as sodium fluosilicate.

Experience has shown that sirup or molasses is not necessary in a bait for cutworms. To prepare the bait, first thoroughly mix the poison with the dry bran. It is important that each particle of bran carry a little poison. Small quantities may be mixed in a container

[1] Prepared in the Division of Truck Crop and Garden Insect Investigations, Bureau of Entomology and Plant Quarantine, Agricultural Research Administration.

by stirring the poison into the bran with a wooden paddle. After the dry mixing is completed, add the water slowly. If large quantities of water are added at one time, the poison will be washed from the bran flakes and there will be difficulty in wetting the whole mass. Large quantities of poisoned bait can be mixed on some flat, smooth surface with the use of a shovel and a rake in much the same manner as concrete is mixed.

In the use of the bait it is good insurance to apply the material before the crop comes up or is set in the field. This is a particularly good practice where the land has been in sod the previous year. Grasslands are likely to have larger populations of cutworms than lands that have been under cultivation. If the bait is being applied to the land before the crop is planted, it should be broadcast late in the evening at the rate of 10 to 15 pounds of the wet bait per acre. If it is being applied after the crop has appeared above ground, it should be distributed along the rows, care being taken to keep as much of it from the plants as possible, as the sodium fluosilicate may cause some plant injury, and an even, light distribution of the bait is as effective as a heavy, uneven distribution.

When handling, mixing, and applying poisonous insecticides, take special care not to inhale dust, fumes, or vapors. Well-designed respirators that afford protection to the entire face are available and should be used when such danger exists. After working with insecticides, wash the hands or any exposed parts of the body thoroughly. Containers in which these materials are being kept or stored should be labeled plainly and placed under lock and key, or at least out of reach of irresponsible persons or children. Any unused portions of these poisonous preparations, as well as receptacles in which they have been mixed, should be treated likewise.

CABBAGE LOOPER

The cabbage looper feeds on lettuce and, unless controlled, may cause serious loss to the crop during some seasons, particularly in Florida, California, and Arizona. Its control when the crop is in the seedling stage is not particularly difficult, but it is more so after the market leaves have begun to form.

This is because the use of arsenical or fluorine compounds after the period of growth, when the leaves that are to go to market are exposed, may result in poisonous residues which would be harmful to the consumer.

The most satisfactory control for the looper during the last stages of the crop's development is the use of dust mixtures containing at least one-half of 1 percent of rotenone. The most effective mixture is one containing three-fourths of 1 percent of rotenone. If rotenone dust mixtures are not available, pyrethrum dust mixtures containing at least 0.2 percent of total pyrethrins are recommended as a substitute. Emphasis should be placed on the control of the loopers in their early stages of development, as both the rotenone and pyrethrum compounds are more effective against the immature loopers than against the larger ones. These dust mixtures should be applied at the rate of 20 to 25 pounds per acre. If the ½-percent-rotenone mixture is used, a higher

poundage per acre will be required than if the ¾-percent mixture is used.

Unfortunately there are no safe and effective substitutes for rotenone or pyrethrum for use on lettuce after the formation of marketable leaves. Therefore no insecticide should be applied if these materials are not available.

For the control of the loopers on the seedling crop—that is, from 35 to 40 days before harvest—calcium arsenate or cryolite can be used. The calcium arsenate can be applied in the undiluted form and the cryolite by dilution with equal parts of talc. The dust should be applied at the rate of 20 to 25 pounds per acre per application. A thorough covering of the leaves is essential to effective control.

In a spray form the calcium arsenate or cryolite should be used at the rate of 2 to 3 pounds per 50 gallons of water and applied at the rate of 100 to 125 gallons per acre for each application.

If the seedling crop is infested before thinning, the plants left standing are liable to severe injury, as loopers on the plants that are pulled will leave them as soon as they begin to wilt and move on to the plants left standing. In sections where early infestations are likely to occur it is a good practice to treat the lettuce seedlings before thinning.

APHIDS AND OTHER PESTS

Aphids, or plant lice, occasionally become troublesome on lettuce, and a useful remedy is nicotine. The nicotine can be applied either in the form of a spray or as a dust. The dust should contain 2 percent of nicotine. Nicotine dusts are not effective at low temperatures, and where possible the treatments should be made when the air temperature is above 70° F. and when the foliage of the plants is dry. It is important that the dust applications reach the innermost parts of the plants, as the nicotine kills the aphids only when it comes in contact with them. Dusting operations, either for the looper or for aphids, are more effective if carried on when there is little wind movement. A cloth trailer attached to the rear and above the dust boom is very helpful in holding the dust over the plants for a short time after it is discharged from the duster. Such a trailer is always useful in holding the dust but is especially effective when the wind velocity is above 5 miles per hour.

Satisfactory control of armyworms and the corn earworm can be obtained by the methods that are used against the cabbage looper when its attacks take place on the crop in the early stages of growth. Rotenone and pyrethrum, however, are ineffective against these pests; consequently no satisfactory remedy has been developed for their control on the lettuce crop as it approaches maturity.

The use of arsenical or fluorine compounds at this time would leave a harmful residue on the marketed product.

Under some conditions wireworms can be effectively controlled by the application of naphthalene to the soil. The control by soil fumigants is an exacting process, as success depends upon the condition of the soil and the location of the wireworms in the soil at the time of treatment. Therefore lettuce growers who are concerned with the wireworm problem should consult their State entomologist or the Bureau of Entomology and plant Quarantine, United States Department of Agriculture.

HARVESTING, HANDLING, AND SHIPPING

HEAD LETTUCE

Head lettuce should not be harvested until mature unless market and weather conditions justify premature cutting. During a period of very warm weather a few days' delay in cutting the crop may mean much loss from bolting and from tipburn and other diseases. The marketing of immature, low-grade lettuce reduces the market price for the high-grade product. When mature and ready to harvest the heads are solid and the tops of the heads have a light-yellowish color.

In harvesting head lettuce the plant should be cut at or slightly below the soil surface, leaving as many of the wrapper leaves uninjured as possible. The soiled and partially spoiled leaves on the base of the head should be removed in trimming for packing. Head lettuce intended for distant shipment should not be cut immediately after a heavy rain or an irrigation or in the very early morning, because the plants may be gorged with water and the outer or wrapper leaves are then easily broken or destroyed in handling. Head lettuce to be shipped to distant markets should retain as many sound wrapper leaves as possible, to protect the heads in transit. If it is necessary to harvest head lettuce when the leaves are very brittle from rapid growth and high water content, the heads should be very carefully cut and turned butt up for a short time to permit the outer leaves to wilt slightly, after which the heads can be handled with less danger of breaking or destroying the wrapper leaves. Excessive wilting should be avoided.

Head lettuce for distant shipping is generally trimmed and packed without being washed, but for local or nearby markets it is often washed and drained before packing. Although washing is often necessary in some eastern districts to remove soil splashed on the leaves by rain, it is unnecessary in the irrigated districts of the West, where the rainfall is very low.

In some of the Eastern States it was formerly a general practice to pack head lettuce dry in the field and ship it without icing the containers. Many of the more important eastern districts are now following the method used throughout the West: hauling the untrimmed heads to a central packing shed in dumpcarts, trailers, or lug boxes, where the heads are trimmed, graded, and packed in paper-lined crates with some ice in the container. This method assures its arrival in the city markets in better condition than is possible where field packing is practiced. Lettuce packed in the field cannot be graded as carefully as that packed in a central packing house, and it is difficult to prepare attractive packages under field conditions.

The United States Department of Agriculture has formulated specifications for standard grades for head lettuce, which are being used more extensively each year. Copies of these may be obtained from the Office of Distribution, War Food Administration, United States Department of Agriculture, Washington 25, D. C.

Lettuce was formerly marketed in packages of numerous shapes and sizes, but now only a few standard containers are in use. Almost all the western lettuce is marketed in the large, standard western crate, which is approximately 13½ by 17½ by 21½ inches. Crates having minor differences in these measurements are used in different

localities. In the West a 9- or 9½- by 13- by 21⅝-inch crate—the so-called half, or pony, crate—is also common.

These two containers, or crates of similar dimensions, are now being used very generally throughout the East. The hamper, formerly common in the East, is now used only to a limited extent, as in Florida.

Before being packed, the crates are usually lined with heavy paper so placed as to lap over the top and bottom, completely enclosing the contents after the crate is filled. The heads are packed in layers with the stems upward. The number of heads per crate varies according to the size of head, the large western crate containing 36, 42, 48, 54, or 60 heads per crate. The 4-dozen size is considered the most desirable. Usually 24 heads are packed in the half crate, but the number varies, depending on the size of the heads. From 20 to 30 pounds of crushed ice is placed between the layers and on the top layer in the large crates. Enough lettuce and ice should be put into the crates to cause about 1-inch bulge both top and bottom when the lid is brought down for nailing in the press.

Lettuce is a perishable crop and requires extreme care in handling. Cutting, loading, trimming, and packing should be done with care to avoid destroying the wrapper leaves and bruising the heads. The cut heads should be protected from the sun and wind as quickly as possible by hauling them to the packing shed. The more promptly the cut heads are trimmed, packed, iced, and placed in refrigerated cars or trucks the better will be the chance for the product to reach the city market and the consumer in good condition.

Many large growers and shippers market their lettuce under their own brand names, in which case a paper label bearing the brand name is pasted on one end of the crate prior to packing. Smaller growers usually have their product identified by a grower's number stamped on the crates. The number of heads per crate or some other indication of size or quality is also stamped on each crate.

The packed crates should be lidded and placed in a precooled car or truck as soon as possible. The loaded cars are provided with ice to maintain a low temperature during transit. The amount of ice used and its distribution in the car depend upon the season of the year and the distance to market. It takes 9 or 10 days for cars from the Pacific coast to reach the large eastern markets. In periods of high temperature top or body icing is used in addition to bunker icing. During the cooler months bunker icing is often omitted and only a heavy top icing is used.

The lettuce crop from the South Atlantic States is moved to the northern markets in refrigerator cars and trucks. The use of the latter in the shipments from the South has increased during the past few years. The lettuce growers of the Eastern States have the advantage of a short haul to the large consuming markets, with lower freight and refrigeration costs and the additional advantage of being better able to take advantage of fluctuating market demand and prices.

OTHER TYPES OF LETTUCE

Cos lettuce is prepared for market in much the same manner as head lettuce. Most of it is packed in the half crate with or without ice.

Leaf lettuce is grown in a limited way as an outdoor crop for local market. The varieties Early Curled Simpson and Grand Rapids are used mainly for this purpose. Grand Rapids is grown extensively in greenhouses during the fall and winter months, especially in Michigan, Indiana, Ohio, western Pennsylvania, and western New York. Although it is sometimes shipped to the large markets in solid carlots, most of the leaf lettuce is shipped in smaller lots by either express or motortruck. Leaf lettuce is usually marketed in 14- and 22-quart, square-cornered, splint baskets holding from 6 to 10 pounds, in 1-bushel standard stave baskets holding 15 pounds, and in standard 3-bushel barrels. It is sold mainly by the pound. Some leaf lettuce is grown in coldframes during early spring and sold locally to stores and consumers. Standard containers are not generally used for this lettuce, but any crates, baskets, or boxes that may be available are used for delivery to the stores.

Stem lettuce has been grown mostly in home gardens for family use, but after the leaves have been removed the stems may be marketed in bunches like asparagus and broccoli.

SOME ECONOMIC ASPECTS OF LETTUCE PRODUCTION

From 1918 to 1931 there was an uninterrupted annual increase in the acreage planted to lettuce in the United States. According to the Bureau of Agricultural Economics, United States Department of Agriculture, 15,840 acres were planted in 1918 and this was increased to an all-time high of 175,430 acres in 1931. Most of this expansion was in the irrigated districts of the West. Production began to exceed the demand at good prices, and the eastern markets were flooded with lettuce at prices often barely above the cost of packing and transportation.

After the peak was reached in 1931, there was an abrupt drop in the lettuce acreage and since then it has fluctuated as much as 25,000 acres in two successive years, with the average annual acreage about 155,000.

During the period of expansion of the industry and afterward there was a more or less steady decline in the number of crates harvested per acre. From 1918 to 1922, inclusive, the yield of lettuce per acre averaged 225 crates holding about 70 pounds. For the following 10-year period the yield declined to 149 crates, with a further drop to 137 crates per acre for the period from 1933 to 1942.

Much of this decline in the yields of lettuce per acre resulted from attempts to expand the industry into areas which because of climatic, soil, or other conditions are not well adapted to lettuce production and from the failure to cut lettuce because of low prices due to glutted markets. This statement is supported by the fact that during the years in which the largest acreages were planted, 1930 and 1931, the number of crates cut per acre dropped to 114 and 112, respectively. This decline in yield per acre occurred during a period when great advances were made in the introduction of new disease-resistant and better adapted varieties, some of which have made lettuce production profitable in districts where little lettuce was formerly grown. On the other hand, some of the districts where the industry was overexpanded have been almost abandoned as centers of lettuce production, on account of their inability to compete successfully with other more favorably located districts.

The expansion of the head-lettuce industry throughout the West was accompanied by a decline in the East. Eastern growers had grown mostly the butterhead type and the demand for this kind of lettuce declined rapidly in favor of the more solid, crisp type of lettuce grown throughout the West. The crisphead New York and Imperial strains then being grown in the Western States proved to be poorly adapted to eastern conditions, and eastern growers were faced with the loss of the market for their product.

Some of the recently introduced strains of crisphead lettuce, Imperial 847 and Imperial 44, have proved fairly well adapted to the East, and the future of the industry there looks brighter. Some shifting of the important production centers may be expected as other new disease-resistant and better adapted strains are introduced, and as other crops compete more keenly with lettuce in the present districts.

Since 1930 there has been only a slight increase in the consumption of lettuce and there is no indication of any increase that would justify marked expansion of production.

The cost of production varies with the locality, but lettuce under nearly all conditions is an expensive crop to produce. It requires good land, large quantities of fertilizer, and much expensive hand labor. Profitable yields can be obtained only on the best land, favorably located and wisely tilled. High-quality production and rigid standardization are necessary to maintain and develop the demand for lettuce. The marketing of low-grade lettuce at certain times has done much to lower prices and reduce demand.

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